RECENT WORK BY GABRITSCHEVSKY ON THE INHERITANCE OF COLOR VARIETIES IN *VOLUCELLA BOMBYLANS*.[1]

By Clyde E. Keeler.

The large syrphid flies of the genus *Volucella* have long been in taxonomic confusion due to their great variation in Color. In Europe there are several forms which closely resemble certain species of bumble-bees and as the flies are parasitic in the nests of these bees, the color varieties have taken on considerable significance on account of their apparent mimetic resemblance to the specific bees on which they are parasitic.

Recently Gabritschevsky[2] has reported on a number of crosses between three varieties and has shown that they bear a Mendelian relation to one another something like that found by De Meijere[3] to exist between the forms of polymorphic *Papilio memnon* in Java.

While I do not share the belief that a Mendelian analysis eliminates the problems of mimicry and protective resemblance, by causing them to disappear, I do maintain that proof of such an hereditary status sheds much light in the proper direction of a solution and suggests a possible mode of attack upon allied problems in these fields.

As early as 1901 a mating pair of *Volucella bombylans* var. *bombylans* and *Volucella bombylans* var. *plumata* was reported by Verrall.[4] It is quite probable that there is free interbreeding between these as well as other color varieties of this species.

Gabritschevsky has worked with a very difficult material and has obtained results of great merit. However, he has hardly

[1]Contribution from the Entomological Laboratory of the Bussey Institution, Harvard University, no. 259.

[2]Gabritschevsky, E. Farbenpolymorphismus und Vererbung mimetischer Varietaten der Fliege *Volucella bombylans* und auderer "hummelahnlicher" Zweiflügler. Zeitschr. f. indukt. Abstamm. u. Vererbungslehre, Vo. 32, 1924, pp. 321-353.

[3]Meijere, J. C. H. de, Uber Jacobsons Züchtungsversuche bezüglich des Polymorphismus von *Papilio memnon* L. ♀ und über die Vererbung sekundarer Geschlechtsmerkmale. Zeitschr. f. indukt. Abstamm. u. Vererbungslehre,

[4]Verrall, British Flies, Vo. 8, p. 485. London, 1901.

done justice to himself or his material, for although he tabulates the data and shows that they may all fit a simple Mendelian scheme, yet he does not attempt to show the snugness of this fit. This I have tried to do, for one is not content with knowing that an hereditary formula may be applied successfully, but desires as well to know the probability of its being the most exact interpretation possible for the given facts. It is when too many multiple factors, lethals, normal overlaps, distorted chromosomes and the like must be resorted to to elucidate materials of great complexity and difficult handling, that many workers take leave of this form of analysis.

The data under consideration show results of matings between the three varietal forms, *bombylans*, *hæmorrhoidalis* and *plumata*. There are eighteen matings in which both parents are known and twelve in which the mother only was observed. According to the Mendelian scheme as given by Gabritschevsky there are twenty-one different genetic types of matings possible.

Among the forms considered there are two pairs of alternatives. Either the thorax and base of abdomen are black or they are yellow with a rusty red tinge on the central portion of the mesonotum. The fourth abdominal segment is either rusty red or white.

The black thorax and red abdomen are characteristic of *bombylans*. The yellow thorax and red abdomen distinguish *hæmorrhoidalis* from *plumata* which bears the yellow thorax and white abdomen.

The fourth possible combination, that of a black thorax and white abdomen does not appear in nature. This may be taken to mean that the presence of a black thorax tinges the abdomen regardless of those factors affecting it specifically. True it is that there is variation in intensity of the rusty red abdominal color in *bombylans*. Such a condition would give us reasons for at least three such variations according to whether the specific color factors which the animal contained were homozygous for red, for white or heterozygous for both.

In Kurst Stad (Russia) the three color varieties are distributed in the proportion of 50% b; 20% h; 30% p. If we assume distribution and equal interbreeding of all the genetic types (given in Gabritschevsky's Table II) we may expect animals appearing in the proportion of the three types shown in the table. If we convert the tabular figures into percentages we find that they give us an expectation of *about* 53% b; 14% h; 33% p. However, these ratios will shift from year to year in nature and instead of having equal numbers of six genetic types the second year to breed from there will be six types in the ratios (6+17+17) *bombylans*, 7 *hæmorrhoidalis*, 16+6 *plumata*, causing the gradual piling up of the heterozygous classes.

The percentages for the region near Moskow are also given. It is marked by a dearth of the dominant *bombylans*. These are 20% *bombylans*, 30% *hæmorrhoidalis*, 50% *plumata*. A shift caused by interbreeding could not take care of these ratios. True it is that the presence of even 20% *bombylans* will distort the relative appearance of *hæmorrhoidalis* and *plumata* types. If, however, we neglect this and compute the percentages for the two varieties of yellow thoraxed flies observed, we find that about 62.5% of them were p. and 37.5 were *hæmorrhoidalis*. When we consult the table mentioned above and classify the animals resulting from yellow thoraxed parents we find that we should expect 70% *plumata* and 29.1% *hæmorrhoidalis*.

The above is entirely a theoretical consideration. Actual numbers are not given in the text. Percentages for these two places only are given. It is unknown whether or not these percentages were based on fair samples of the population.

I prefer to use Mendel's type of formulæ for simplicity's sake.

Let Y = black thorax
y = lack of black thorax=yellow thorax
W = white abdomen
w = lack of White abdomen=red abdomen

Then a *bombylans* may be:

YYww		*YYWW*
Yyww	possibly	*YYWw*
		YyWW
		YyWw

A *plumata* is:

$yyWw$
$yyWW$

A *hæmorrhoidalis* is:

$yyww$

Bombylans and *plumata* may or may not breed true, but *hæmorrhoidalis* always does.

The simplest expianation is that the combinations of thorax and abdomen are closely linked or that the three color phases are allelomorphic.

If we classify the recorded matings by the types or classes of offspring produced we find that the results fall readily into one or more of the twenty-one theoretical combinations.

There is a single exceptional individual. It is in the case of a *hæmorrhoidalis* male appearing in what should be a *plumata* group only. It may be an individual variation resmbling *hæmorrhoidalis* or a case of mutation. Non-disjunction and contamination might account for its appearance. It might be a badly distorted ratio, for one possible mating could produce these in the proportion of 3:1. In a number of instances only a single type of mating can account for the results obtained. In others several combinations could have produced the observed classes in the same proportions. It is impossible to distinguish between homozygous and heterozygous dominants in either parents or offspring unless a very detailed genetic study could be successfully carried out.

If we consider that those matings which produced like results in the F_1 were identical, although in a few cases there is a chance to the contrary, we may combine these data. We may then calculate the expectancy under such conditions. The calculated sizes of the classes expected may then be compared with the numbers of individuals in each class actually obtained.

Upon comparing the expected values with the numbers observed, it is evident that there is a much better agreement than could possibly be found due to chance alone.

Let us now examine these results as I have analysed them by the statistical method.

TABLE I.

Matings Combined	Probable type of Mating	Expected	Found	Deviation divided by probable Error	Probable occurence of such deviations due to chance alone during 100 repetitions of the same experiment, other things being equal.
1, 2, 3, 4	3, 11, 12, 15, 17, 18	83.5:27.5	82:29	0.4	
5	1, 7, 8	17 5:17.5	19:16	0.7	
6, 7, 8	2	34.5:11.5	36:10	0.7	
10, 11	9	16:0	16:0	0.0	
12	5	17:17	11:23	3.0	4.3
9, 13, 14	13	25.5:25.5	25:26	0.004	
15	4	16:0	16:0	0.0	
16? 17? 18?					
19, 23, 24	18	46:46	52:40	1.8	22.47
20, 21, 25, 26, 27, 28	6, 20, 21	47:0	46:1	cannot be calculated	
22, 29, 30	19	46:46	46:46	0.0	

In this analysis I have accounted for some 540 individuals resulting from 27 matings. I have omitted three matings (Nos. 16, 17 and 18) in which we cannot be sure what the parents were genetically and in which we cannot recognize the ratios definitely.

The results from a mathematical standpoint are close approximations of those expected. The highest deviation from the expected for any group is barely three times the probable error. This, from a statistical point of view, is probably insignificant. The same deviation would be expected under normal conditions of chance 4.3 times in 100 repetitions of the same experiment, other things being equal.

It is to be desired that a test of this kind be applied to the American relatives of these flies, for it is quite probable that their differences may have a similar hereditary basis.

Conclusion.

The results obtained by Gabritschevsky in studying the relationships between *Volucella bombylans*, var. *bombylans*, *V. b. plumata* and *V. B. hœmorrhoidalis* agree very closely with ratios expected upon a mendelian interpretation, a condition hardly to be predicted from an undetailed perusal of the genetical data as presented by this experimentor.

Book Review.

Manual of Injurious Insects, By Glenn W. Herrick. Henry Holt & Co., New York City, 1925. $4.50.

This is a book of 489 pages including its index, with 458 text-figures. It deals mainly with the more abundant North American insects that affect agricultural crops although there are short chapters dealing with the parasites of poultry and livestock and a few words on the relation of insects to human and animal diseases. It includes also a rather elaborate consideration of insecticides and the machinery for applying them. Forest insects are entirely omitted.

The several pests are dealt with *seriatim*, classified according to the crops upon which they feed. For each species there are paragraphs entitled "Description: Injury; Life history, and Control measures," together with a figure of the insect or its work and a list of such useful practical literature as has been published by the Federal government and the various state agricultural experiment stations. Less common pests are listed by their common and scientific names with references to economic literature.

Professor Herrick's book forms a useful compendium and with its abundant references will also furnish a key to the literature for those who wish to learn more concerning certain species.